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The multiple roles of grassland in the European bioeconomy

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M. Höglind
A.K. Bakken
K.A. Hovstad
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The effect of selected soil and climate parameters on multiple ecosystem services from abandoned and managed semi-natural grasslands

Johansen L.[1], Wehn S.[1] and Taugourdeau S.[1,2]
[1]NIBIO – Norwegian institute of Bioeconomy Research, Stjørdal, Norway; [2]CIRAD UMR SELMET, Montpellier, France; line.johansen@nibio.no

Abstract

Climate, available resources and disturbance by agricultural land use influence ecosystem service (ES) delivery. In our project we studied how ES provision from managed and abandoned semi-natural grasslands vary along soil and climatic gradients. Information on climate (temperature and precipitation) and soil (pH-value and phosphorous content) were used to test whether ES varied along these environmental gradients. 13 ES indicators were calculated and assigned to nine ES. Some of the ES varied along the gradients, but the results indicate that the effects of soil and climate on ES are modified by agricultural land use.

Keywords: grazing, indicator, boreal ecosystem, land use change, plant species

Introduction

Semi-natural grasslands with high biodiversity provide several ecosystem services (ES; Bullock *et al.,* 2011). These ES are related to the biological characteristics of ecosystems and plant community surveys can therefore be used to measure ES at local scales (Kremen, 2005, De Bello *et al.,* 2010). Characteristics of plant communities can be species composition, functional traits, and vegetation structure. Delivery of one ES often depends upon several characteristics of the ecosystem, and within one ecosystem, bundles of ES interact (Lavorel *et al.,* 2010). Climate, available resources and disturbance by agricultural land use are some of the underlying environmental gradients that influence the characteristics of the communities in an ecosystem (Diaz *et al.,* 2007; Lavorel and Garnier, 2002). Therefore, to achieve knowledge about mechanisms that control ES delivery, the characteristics along environmental gradients have to be studied (Dorrough *et al.,* 2006; Lavorel *et al.*, 2011). The aim of this project was therefore to evaluate how ES provision from managed and abandoned semi-natural grasslands varies along soil and climatic gradients.

Materials and methods

We selected nine ES and defined 13 associated vegetation characteristics (indicators) (De Bello *et al.,* 2010, Duru *et al.,* 2012; Ford *et al.*, 2012, Pakeman, 2014, Vinge and Flø, 2015). The indicators are based on botanical surveys, functional traits (databases LEDA (Kleyer *et al.*, 2008), TRY (Kattge *et al.,* 2011)), information about the plant species as resources for pollinators (the Biological Records Centre's database of insects and their food plants) and allergy inducing pollen providers (information provided by the Norwegian asthma and allergy association). Plant community surveys were conducted on 112 subplots (4 m^2) within 14 Norwegian boreal sites including one manged and one abandoned semi-natural grassland. The ES indicators were transformed into notations between zero and one using negative or positive linear transformation using the TATALE tool (site http://umr-selmet.cirad.fr/en/products-and-services/proposed-products/tatale). Bundles of indicators related to one ES (see Table 1) were then aggregated using weighted mean values of the notations. The environmental data used in our analyses originate from soil samples (pH-value, available phosphorous (P)) and from the WorldClim database (http://www.worldclim.org/bioclim; mean annual temperature (MT), annual precipitation (AP)). Mixed linear modelling (site as a random) using the lmer4 package in the R software (R Core

team 2015) was used to test the influence of environmental variables on ES in managed and abandoned semi-natural grasslands, separately.

Results and discussion

There was a positive effect of soil pH-value on genetic resources in both managed and abandoned semi-natural grasslands and on forage stability and aesthetics in the abandoned semi-natural grasslands (Table 1). Available P in the soil showed a negative influence on genetic resources and positive influence on allergy control, but only in managed sites. These results are linked to the higher species richness found in calcareous (Vandvik and Birks, 2004) and phosphorous poor soils (Dorrough *et al.,* 2006). Higher plant species richness causes higher diversity of herbs and flower colours, which are appreciated (De Bello *et al.,* 2010; Ford *et al.,* 2012), but it also increases the resilience of forage provision (Pakeman *et al.,* 2014). Fewer species on the other hand, give less allergy-inducing pollen producers (higher allergy control). We found lower delivery of pollination service with increasing level of phosphorus in the abandoned site but less nutrient turnover and forage quantity. No ES except allergy control varied along the climatic environmental gradients. In the abandoned semi-natural grasslands, allergy control decreased with both increased precipitation and temperature.

Table 1. The estimated effects (+: positive ($P<0.05$); -: negative ($P<0.05$); ns: ($P>0.05$)) of soil and climate on ecosystem services (ES) delivery in managed and abandoned semi-natural grasslands.

ES indicator	ES	Effect of soil				Effect of climate			
		Managed		Abandoned		Managed		Abandoned	
		pH	P	pH	P	MT	AP	MT	AP
Number of species	Genetic resources	+	–	+	ns	ns	ns	ns	ns
Abundance of legumes	Nutrient turnover	ns	ns	ns	+	ns	ns	ns	ns
Leaf dry matter content[1]									
Specific leaf area[1]									
Abundance of allergy pollen producers	Allergy control	ns	+	ns	ns	ns	ns	–	–
Abundance of butterflies attractive plants	Pollination	ns	ns	ns	–	ns	ns	ns	ns
Abundance of Hymenopteran attractive plants									
Leaf dry matter content[1]	Forage quantity	ns	ns	ns	+	ns	ns	ns	ns
Specific leaf area[1]									
Leaf nitrogen content[1]	Forage quality	ns	ns	ns	ns	ns	ns	ns	ns
Abundance of graminoids									
Functional richness of leaf dry matter content	Forage stability	ns	ns	+	ns	ns	ns	ns	ns
Abundance of herbs	Aesthetics	ns	ns	+	ns	ns	ns	ns	ns
Number of flower colours									
Cover of canopy layer	Attractive-ness	ns	ns	ns	ns	ns	ns	ns	ns
Cover of shrub layer									

[1] Community weighted mean.

Conclusions

Overall, we found a stronger influence of the environmental gradients on ES in the abandoned site compared to the managed semi-natural grassland, indicating that agricultural land use practices such as sheep grazing modify effects of climate and available resources in soil.

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